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DISTRIBUTION OF A LEAF VEIN GALL IN *Caryocar brasiliense* (CARYOCARACEAE) TREE[1]

GERMANO LEÃO DEMOLIN LEITE[2*], VINICIUS MATHEUS CERQUEIRA[2], VINICIUS DE ABREU D'ÁVILA[2], CARLOS HENRIQUE PIRES MAGALHÃES[2], GERALDO WILSON FERNANDES[3]

ABSTRACT - We studied the spatial distribution of a galling insect species that induces galls on the leaf veins of *Caryocar brasiliense* Camb. (Caryocaraceae) trees. Galls/leaflet predominantly occurred at the northern (1.06) tree slope, with decreasing number at the western (0.92), eastern (0.65), and southern (0.60) slopes. Higher number of galls/leaflet were found in the interior of the tree crown, i.e., on the proximal region (1.99) of the stems compared to the terminal portion (1.26). On the other hand, the average number of vein galls/leaflet did not differ statistically among the three leaflets of *C. brasiliense* (right = 0.79, central = 0.78, left = 0.84). Galls/leaflet were most abundant on the distal (0.46) and median (0.52) regions compared to the proximal (0.24) longitudinal region of the leaflet. This gall/leaflet insect was most frequent on the central (1.01) portion than in the leaf margin (0.05) or near mid vein (0.14) on transversal regions of a leaflet.

Keywords: Savanna. Insect distribution. Leaf galls. Brazil.

DISTRIBUIÇÃO DA GALHA DAS NERVURAS FOLIARES NA COPA DE *Caryocar brasiliense* (CARYOCARACEAE)

RESUMO – Registramos a distribuição espacial de um inseto galhador que induz galhas nas nervuras foliares em árvores de *Caryocar brasiliense* Camb. (Caryocaraceae). Mais galhas/folíolo foi encontrado na face norte (1,06), seguido pelo oeste (0,92), leste (0,65), e sul (0,60) no dossel das árvores. Mais galhas/folíolo foi observado no interior da copa das árvores, como exemplo, mais no interior do ramo (1,99) comparado com a porção terminal do mesmo (1,26). Por outro lado, o número de galhas nas nervuras foliares/folíolo não diferiu significativamente entre os três folíolos de *C. brasiliense* (direito = 0,79, centro = 0,78, esquerdo = 0,84). Mais galhas/folíolo foi notado na região distal (0,46) e mediano (0,52) comparado com a região proximal (0,24) no eixo longitudinal do folíolo. Essa galha/folíolo foi mais freqüente no centro (1,01) do que na margem foliar (0,05) ou próximo a nervura principal (0,14) no eixo transversal do folíolo.

Palavras-chave: Cerrado. Pequi. Distribuição de inseto. Inseto galhador.

*Autor para correspondência.
[1]Recebido para publicação em 29/11/2010; aceito em 09/05/2011.
[2]Insetário G.W.G. de Moraes, ICA-UFMG, av. Universitária,1000, Universitário, Caixa Postal, 135, 39404-006, Montes Claros - MG; gldleite@ig.com.br; vinicius.matheus@gmail.com.br; viniciusabreu2@hotmail.com; magalhaes_insecta@yahoo.com.br
[3]Ecologia Evolutiva & Biodiversidade/DBG, Caixa Postal 486, ICB/UFMG, 30161-970, Belo Horizonte - MG; gw.fernandes@gmail.com

INTRODUCTION

Insect galls are known to distribute differentially within and among organs of their host plants. Many galling larvae achieve higher density, size, and even higher performance at the proximal portion compared to more distal portion of the leaf. For instance, *Pemphigus betae* Doane (Hemiptera: Aphididae) individuals that induce galls on the most proximal portion of the leaves of *Populus angustifoliae* James (Salicaceae) reach higher fitness compared to those that attack the distal parts of the leaves (WHITHAM, 1978; AUSLANDER et al., 2003). The mechanism influencing the differential distribution within *P. angustifoliae* leaf was the more rapid and efficient interceptation of plant photosynthates at the leaf base according to Whitham (1978). A similar trend was reported by De Souza et al. (1998, 2001) when studying the galls induced by *Collabismus clitellae* Boheman (Coleoptera: Curculionidae) on the base of the stems of its host plant *Solanum lycocarpum* St. Hil. (Solanaceae). Also galls reached higher density at the leaf margins (LEITE et al., 2009). A combination of leaf trichome density, extra-floral nectaries and natural enemies may be responsible for the trends found, as they are known to have a strong influence on the behavior, selection, and performance of insect herbivores (WOODMAN; FERNANDES, 1991; FERNANDES; PRICE, 1992; FERNANDES, 1994).

Insect galls may also distribute differentially between habitats as well as within the host crown. Plants in sunny and dry habitats are known to support higher density of galls compared to plants in shaded habitats (FERNANDES; PRICE, 1992; AUSLANDER et al., 2003; LEITE et al., 2009). Differential sun exposure may influence the quality of the host plant tissue as well as the gall tissue or even the plant ability to find and elicit induced responses to the invading organism (FERNANDES, 1990; FERNANDES et al., 2000, 2005). Furthermore, natural enemies could also be strong selective forces against galling on more favorable, shaded habitats (FERNANDES; PRICE, 1992). Therefore, differential selection could lead to female preference and larval performance for foliage in sunny habitats.

Caryocar brasiliense Camb. (Caryocaraceae) is one of the most common and important plant species in the dry and harsh semi arid vegetation of Brazil, called cerrado (LEITE et al., 2006a, DE ARAUJO; PIRES, 2009). Its fruits are used by humans for food, production of cosmetics, lubricants, and in the pharmaceutical industry, representing the main source of income of many communities (LEITE et al., 2006a).

It is host to a large number of invertebrate and vertebrate herbivores (OLIVEIRA, 1997; LOPES et al., 2003; FERNANDES et al., 2004; LEITE et al., 2006b). Among the herbivores that attack *C. brasiliense*, galling insects are the most abundant (OLIVEIRA, 1997; LEITE et al., 2007, 2009).

This is the first report of the within tree distribution of a gall-maker herbivore, probably *Bruchophagus* sp. (Hymenoptera: Eurytomidae) (unpublished data) on *C. brasiliense* foliage. This study was conducted to determine whether gall abundance would differ among the three leaflets on a single leaf of *C. brasiliense*. Second, To assess the effect of foliage slope orientation on the gall abundance. A third objective was to determine the gall distribution on the leaves along the host stem (within tree); and finally we determined the within leaf (longitudinal) gall distribution, and transversal location of galls within leaves, because the grouping of galls on a given leaf portion may indicate site preference (WHITHAM, 1978).

MATERIAL AND METHODS

This study was carry out at a locality known as "Abóboras", in Montes Claros, Minas Gerais State, Brazil (43° 55' 7.3" W, 16° 44' 55.6"S, 750 m a.s.l.), in Juny 2006. The north of Minas Gerais State has a climate Aw: tropical of savanna, according to the classification of Köppen, with dry winter and rainy summer. The vegetation is Cerrado (savanna) under several human disturbances, and the soil is dystrophic red yellow latosol of sand texture. During the field study the average temperature was 19.0 °C; air relative humidity 68.0%, month round accumulated precipitation of 0.3 mm; winds prevailed from the northeast at an average speed of 1.70 m/s; insolation 8.3 h (Main Climatic Station of Montes Claros of the 5th DISME-INMET).

The vein gall (Figure 1) density on *C. brasiliense* leaves is scarse and highly variable among trees (unpublished data). Ten trees having the vein gall infestation were chosen to perform the study. Trees had on average 1.17 ± 0.08% (minimum: 0.0; maximum: 20%) of leaf coverage with this gall (average: 0.80 ± 0.06; minimum: 0.0; maximum: 24 galls/leaflet). To evaluate the distribution of galls within the tree crown, the number of galls were recorded on the compound leaves of *C. brasiliense* of four randomly selected stems positioned (LEITE et al., 2009) on north, south, east, and west facing sides of ten adult trees (average height: 4.04 ± 0.3 m; average crown width: 4.73 ± 0.5 m; average diameter at breast height: 21.95 ± 6.1 cm).

To evaluate the distribution of galls among the leaflets we recorded: i) gall abundance according to foliage orientation (slope); ii) the differential abundance of galls on the right, central, and left leaflets (LEITE et al., 2009); iii) gall abundance on the distal, median, and proximal region of a leaflet (LEITE et al., 2009); and iv) gall abundance on the leaflet border, central area, and adjacent to the mid leaf vein of the leaflet (LEITE et al., 2009). A total of 1,440 leaflets of 480 leaves were inspected for

galls.

All data were transformed to $\sqrt{x} + 0.5$ and were analyzed by Analysis of Variance and means were compared using Tukey test at $P < 0.05$ significance level.

Figure 1. Vein galling herbivore on *Caryocar brasiliense* leaflet.

RESULTS AND DISCUSSION

The average number of vein galls varied according to slope orientation of the tree crown. Vein galls predominantly occurred ($F = 4.956$, $P = 0.00218$) on the northern slope with decreasing number at the western slope, and fewer vein galls on the foliage in the eastern and southern slopes (Table 1). On the other hand, the highest number of *Eurytoma* leaf galls on this same host species were found on the eastern slope compared to the other slopes (LEITE et al., 2009).

These researchers indicated that the foliage on the eastern slope of the host trees are most exposed to higher winds and strong sunlight, since prevalent winds in the region are north-eastern/eastern. Their finding corroborate the hypothesis that galling insects are most abundant on sunlight-exposed foliage (FERNANDES; PRICE, 1988). The reasons for this present finding are unknown but may be related to competition with the major leaf galling insect on *C. brasiliense* leaves, including the *Eurytoma* sp. Future studies on the relationships and phenology of attack may shed light on this trend.

Highest number of vein galls were found ($F = 5.439$, $P = 0.00119$) on the leaves in the interior of the tree crown than at the border; primarily on the leaf position 3. Leaf positions 3 and 4 supported 61.2% of all galls sampled (Table 1). Again, the same trend was found by Leite et al. (2009) when describing the attack pattern of the galling *Eurytoma*. These trends may be influenced by differential mortality caused by natural enemies, and plant resistance (LEITE et al., 2009). Otherwise, most distal leaves (leaves 1 and 2) could also be unapparent or too young to be found by the galling insects at the time of attack while leaves 3 and 4 were exposed to galling for a longer period (LEITE et al., 2009).

The average number of vein galls did not differ statistically ($F = 0.144$, $P = *****$) among the three leaflets of *C. brasiliense* (right = 0.79, central = 0.78, left = 0.84, Table 1). A similar trend was reported by Leite et al. (2009) on the *Eurytoma* sp. galls.

The highest number of vein galls were found ($F = 8.919$, $P = 0.00024$) on the distal and median region compared to the proximal longitudinal region on leaflet (Table 1). On the interaction between the *Eurytoma* and *C. brasiliense* more galls were found on the median region of the leaf. Leite et al. (2009) argued that the trend may have been influenced by the lower density of trichomes in the median portion. Leaf trichomes are known to have a strong influence on the behavior, selection, and performance of insect herbivores (WOODMAN; FERNANDES, 1991; FERNANDES, 1994; AGRAWAL, 2004). Many galling larvae achieve higher density, size, and even higher performance at the proximal portion of the host leaves perhaps because in these areas the interception of photosynthates is more efficient

Table 1. Number of vein galls (± standard error) induced according to stem orientation, position leaves on stem, position leaflet, transversal regions on leaflet, and longitudinal regions on leaflet on *Caryocar brasiliense* trees.

Number of vein galls				
Stem orientation	North	South	East	West
	1.06 ± 0.13 a	0.6 ± 0.08 b	0.65 ± 0.12 b	0.92 ± 0.15 ab
Position leaves on stem	Leaf 1	Leaf 2	Leaf 3	Leaf 4
	0.78 ± 0.13 b	0.48 ± 0.07 c	1.19 ± 0.17 a	0.8 ± 0.12 b
Position leaflet	Right	Central		Left
	0.79 ± 0.10 a	0.78 ± 0.11 a		0.84 ± 0.11 a
Transversal regions on leaflet	Border	Central		Mid vein
	0.05 ± 0.01 b	1.01 ± 0.11 a		0.14 ± 0.03 b
Longitudinal regions on leaflet	Distal	Median		Proximal
	0.46 ± 0.05 a	0.52 ± 0.06 a		0.24 ± 0.04 b

Averages followed by the same letters in the line did not differ statistically at $P < 0.05$ (Tukey test).

(WHITHAM, 1978; DE SOUZA et al., 1998, 2001; AUSLANDER et al., 2003).

Vein galls were found predominantly (F = 72.619, P = 0.00009) in the median portion of the leaflets (Table 1). This trend may be influenced by the higher density of trichomes and/or the number of *Eurytoma* galls at the border of *C. brasiliense* leaflets (LEITE et al., 2009).Vein galls occurred at lower density than the *Eurytoma* sp. galls in the field (unpublished data). Furthermore, the *C. brasiliense* trees more attacked by *Eurytoma* are not so colonized by the vein gall (unpublished data) indicating that additional studies of this system are needed.

CONCLUSIONS

Vein galling herbivore attacks preferentially on the median part of the leaflet in the interior of the branches located on the northern *C. brasiliense* slope. The reasons for this present finding are unknown but may be related to competition with the major leaf galling insect on *C. brasiliense* leaves, including the *Eurytoma* sp. Future studies on the relationships and phenology of attack may shed light on this trend. Furthermore, the *C. brasiliense* trees more attacked by *Eurytoma* almost are not colonized by the vein gall (unpublished data) indicating the need for future studies in this system.

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